

## THE AMAZON RIVER FLOOD.

By DR. HAGMANN.

[Extract translated from *Revista Mensal de Meteorologia*, Rio de Janeiro, Brazil, May, 1922.]

The flood of this year [1921] in the Amazon River was extraordinarily great. The water reached a height beyond that of previous years.

The Amazon River, as a rule, rises until the end of the first fortnight of the month of June. "Saint Antonio is at the head of the water," says the Indian. \* \* \* The flood of the year, 1921, was 20 cm. greater than that of 1918, which old inhabitants thought to have equaled that of 1859.

Laborious, but very interesting, was the work of computing the superficial total of the overflowed areas in the valley of the Amazon in order to have some idea at least of the enormous quantity of water that would be necessary to produce a flood of such proportions.

I am personally convinced that the enormous floods that have recurred in these last years are not so entirely the result of the extraordinary precipitation in the high regions of the Amazon River, as a study of the reports received from the commandants of certain affluents of the Amazon do not show a greater quantity of water. I am of the opinion that the reason of the great floods may lie in part in the constrictions in the mouth of the Amazon. On the front sides of the islands of Bailique, Cavianna, Mexiana, and Marajo is the celebrated bank of sand, "Santa Rosa," many kilometers in width and length, where the water is barely 6 meters in depth. These channels are narrow, tortuous, and liable to constant shifting, and do not permit the entrance of trans-Atlantic ships.

I lived for two and one-half years on the island of Mexiana, and for this reason I know the mouth of the Amazon very well. The mouth extends from Mexiana to Belem, three days' sail by boat, to say nothing of the danger from the wretched climate.

Islands form and disappear as the waves scour and carry the sand loosened from the banks. Points of islands with great trees from the virgin forests fall with the constant erosion of the water, always agitating and dislodging from the outer banks masses of sand that constantly increase, the first foothold for the growth of grass and rushes, and later for the bushes and trees whose seeds were floating around. The dark gray color of the water shows conclusively the quantity of sediment that it carries.

On this account the opinion can not be rejected that in general the mouths of the Amazon have become constricted, leaving not more than sufficient opening for the waters in winter time, thus causing in part the enormous floods of the lower Amazon.

A plotting of the pluviometric data for the stations along the Amazon would contribute much to the solution of this problem, so interesting in connection with the hydrographic knowledge of the "river sea."

*Discussion by the director.*—The director expects to visit various places in the States of Para and Amazon, the flood and rainfall stations, as soon as he has finished a hasty study of the proposition of Doctor Hagmann. The installation of these posts will be completed by Inspector Avellar Figueiredo, as soon as he has completed his mission in some of the Northern States.

An interesting feature of Doctor Hagmann's presentation is his belief in the possibility that the sedimentation in the mouth of the Amazon River causes some of its floods.

It would be advisable to verify this assumption which, a priori, appears to be hardly acceptable, because the tide and the strong-running equatorial on the coast would be sufficiently strong to impede the excessive formation of banks, or bars, at the mouth to such an extent as to retard the passage of flood waters.

A hydrometrical chart would probably better reveal the solution of this interesting problem.—H. C. F.

## FROST-FIGHTING IN THE PECOS VALLEY.

CLEVE HALLENBECK, Meteorologist.

[Weather Bureau Office, Roswell, N. Mex., December 7, 1922.]

Fruit-growing in the Pecos Valley of New Mexico is an attractive proposition or an extra-hazardous one, depending upon the point of view. The quality of the fruit is unexcelled, the abundant sunshine imparts a coloring not attained by the same varieties in other districts, and the leading varieties ripen at a time when the large markets are empty of apples. The Jonathan apples of the Pecos Valley are well known in England. A noted author declared that the discriminating taste of man now demands "caviar from Russia, olives from Italy, apples from New Mexico," etc.

On the other hand, there probably is no other fruit-growing district in the United States that is as liable to spring freezes as is the Pecos Valley. On an average, two freezes occur each spring after the apples are susceptible to injury therefrom, and in only 3 years in the last 18 have unprotected orchards borne full crops. On a 10-year average, the unprotected orchard is only 45 per cent efficient, and this 45 per cent practically equals the current upkeep, taxes, and interest on the investment, leaving no profit to the owner.

During the past seven years there has been a decided resumption of orchard heating in this district. This is in small part due to the fact that for eight years no spring freeze has arrived unheralded, and that such can occur in the future is well-nigh impossible. But the principal

cause of this revival is due to the fact that in the past 10 years unprotected orchards have borne but one full crop, with six total failures, while protected orchards have borne eight full crops in that time. It is now the unanimous opinion of the leading fruit growers that apples can be saved every year, for all the veteran orchardists brought their crops safely through the record-breaking freeze of April 19, 1922; and in 1920 two of them, who did not know when they were whipped, saved full crops against minimum temperatures of 15° and 16°.

The object lesson was clear. Consequently, in 1922 hardly an orchard of commercial size could be found that was not equipped for frost fighting. Every serviceable heater in the valley was impressed into service, several carloads of additional heaters were shipped in, and a few procrastinating orchardists, unable to secure heaters in time, distributed baled weeds and straw through their orchards, to be burned as occasion required.

*Frost fighting.*—Six or seven acres of orchard is about all that one man can properly look after. In small orchards of 30 acres or less the owner and his family, with a hired man or two, are usually sufficient to handle the situation, but in the larger orchard a "frost-fighting squad" is required, and necessarily it must be recruited principally from the town population. The members of any one squad, therefore, are likely to be well scattered

over town, and some arrangement must be made for assembling these men quickly and certainly and for getting them out to the orchard. The following case, which is fairly illustrative, with slight modification, of all, will show the organization and handling of the frost fighters.

The owner of an 80-acre peach orchard employed 15 men (including himself); these were divided into three groups of 5 each, one man in each group acting as foreman and furnishing an automobile for transporting himself and his four assistants to the orchard. The orchard was divided into 12 plots, one to the man, and each man knew exactly where his plot was, as these were marked by numbered boards. In each plot was a thermometer, and the three foremen (one of whom was the owner) did nothing in the orchard except watch these thermometers and superintend the heating when such became necessary. By an ingenious arrangement of the heaters, one-fifth, two-fifths, or four-fifths of them could be lighted, and in each case the lighted heaters would be uniformly distributed. The remaining one-fifth were to serve as a reserve. In addition, two truck loads of filled heaters were kept ready as a "mobile reserve."

The orchardist, who received the warnings direct from the Weather Bureau office, communicated them to each man of his squad, but he also arranged, in the event that emergency night warnings should issue, to call only his two foremen and his own group, leaving the foremen to rouse their own men: in this way some valuable time could be saved.

This method, with some slight variation, was adopted by all the leading orchardists.

Inasmuch as the fruit crop represents the chief source of wealth in this district, recruits for orchard squads were plentiful, and most of them served without compensation. In addition, the local chamber of commerce maintained a list of men willing to serve on short notice, to fill unexpected vacancies in the frost-fighting squads. The morning after a freeze found smoke-begrimed business and professional men, clerks, and laborers straggling into town by automobile loads.

*Dissemination of warnings.*—It is impossible for this office to telephone warnings to each fruit grower, of which there are 113 within the free telephone limits of Roswell and probably as many more in the lower valley districts of Dexter, Hagerman, and Artesia. Prior to 1922, warnings were given only to the seven fruit-frost observers, the four districts—Berrendos, Fairview, South Springs, and Hondo—being within the free telephone limits. But this put a hardship upon some of the observers, who were serving without pay; particularly the observer at South Springs, who had nearly 50 orchardists in his district, and to notify all of them, as he faithfully did, consumed much time.

In 1922 a different plan was adopted. With but two exceptions, all the orchardists within the free telephone limits are on "party" telephone lines. Warnings were given to one individual on each line, with the understanding that he was to communicate it to the remaining subscribers on his line. Volunteers for this service were called for, and immediately most of the orchardists volunteered; each wanted to receive warnings first hand. One was selected for each line, with an alternate in case the first one could not be reached. The names of these "line representatives" were published, so that each orchardist would know on whom to depend for warnings. In this way all the fruit growers around Roswell could be reached with 21 telephone calls.

Similar arrangements were made by the fruit-frost observers in the Dexter-Hagerman and Artesia districts, to whom all warnings were communicated directly from this office.

In addition, it was understood that should emergency night warnings be issued, they would be communicated by this office only to the fruit-frost observers, they in turn to give them to each "line representative" in their respective districts, by whom they would be given to the individual orchardists. In this way, a warning could be spread throughout the valley in half an hour.

Desirous of testing the efficiency of the latter arrangement, a night was selected when minimum temperatures close to freezing were expected. No forenoon or evening warnings were issued. At 2:30 a. m. the four observers within the free telephone limits were called and told to prepare their districts for prompt action. Before the fourth one had been roused automobiles were heard leaving Roswell, and within 15 minutes more automobiles were heard in every direction. After 30 more minutes silence again reigned. The celerity with which the alarm spread was remarkable. The temperature on this occasion hovered around 31° and 32° for two hours, and since the orchardists stood guard from 3 a. m. until sunrise, in the cold, it was not thought advisable to inform them that they had been made the victims of an experiment. Besides, their honest expressions of gratitude for this "watchfulness" of the Weather Bureau office were pleasant to hear.

*Frost forecasting.*—In the Pecos Valley, and presumably in all other irrigated regions of the West, temperature forecasting is beset with difficulties not encountered in eastern districts. It appears that the blossoming time of fruit trees depends upon the mean temperature rather than upon the mean maximum or minimum, in so far as this activity is governed by temperature. The average time of blossoming of apples is the same in the Pecos Valley as in the more humid eastern districts having the same mean temperature. But on account of the large daily range of temperature here (normally 42° in clear weather in the country) apples begin blossoming when the normal daily minimum temperature is but 2° above freezing, and are in full blossom when the normal minimum is only 6° or 7° above freezing. Consequently any condition that can depress the temperature a few degrees below the normal is likely to cause damage to the fruit.

Such depression can easily be produced by a clear night following a cloudy day. Unless checked by condensation or by an inflow of warm air the normal radiational fall of temperature will occur at night regardless of how low the temperature may be in the evening. Many of the cold waves occurring at Roswell, including nearly all that have occurred without warning, were due to a cloudy day followed by a clear night. The average dew point is some 16° below the average minimum temperature, and sometimes is 40° or more below the minimum. Consequently there rarely is any condensation of dew or frost to counteract radiational cooling. Unless the humidity is quite high, evening cooling in the spring is the signal for frost warnings. Actual frost, of course, rarely occurs, even in midwinter.

Hygrometric formulæ, so far as this district is concerned, are absolutely worthless in calculating minimum temperatures. This is due to the great variability of the dew point, which may change as much as 20° or 25° over night. A 12-hour fall in dew point of 65° occurred on one date in the spring of 1918. A shift of the wind nearly always is followed by a considerable change in the dew point; a shift from southeast to southwest can lower

it 20° in three hours. This variability is greater in spring than in any other season. In addition, in still weather there is an area of relatively high humidity over the farming region, due to evaporation from liberally irrigated land. In the spring irrigation is general and is almost at its peak, while the surrounding prairies are, normally, at their driest. It is the same as though about three counties from the Ohio Valley region were transplanted to the arid West; the Pecos Valley is, in fact, a long oasis in a desert. A moderate wind serves to sweep this evaporated moisture away, and the dew point at any hour is a very unreliable indication of what it may be a few hours later.

On account of the moister soil, which normally is covered with growing vegetation, and the higher humidity, over the farming region, radiational cooling is less than over the bare, dry prairie. The difference, in spring, may amount to as much as 8°, and any inflow of air into the valley from the surrounding prairie at that time will be attended by a rather sharp fall in temperature. Such inflow often seems to be in the form of quite limited streams, which may cause large differences in the minimum temperatures recorded at different points. An example of this occurred in connection with the freeze of April 19, 1922, when the minimum temperature was exactly forecast for three substations and within 1° for two more, but with errors of 4° and 7° for the remaining two stations. At one of these stations the observer reported that the fall was caused by "a shift of the wind to southwest," and at the other the fall "attended a shift of the wind from southeast to west." The wind was very light throughout. These conditions can not be forecast, and all the orchardist can do is to have a reserve of heaters ready to meet the emergency when it arrives. The fall of temperature is rarely so abrupt or so large that a watchful frost fighter can not successfully combat it with reserves. Then there is air drainage down the Pecos Valley, and secondary drainage eastward down the tributary valleys, which may cause sharp falls in temperature of as much as 12°. Since this normally occurs on clear, still nights in spring, it usually can be foreseen and allowed for in calculating the minimum temperature. It is very treacherous, however. It moves slowly, and the change in wind direction may occur without being noticed. The drop in temperature often is very abrupt. In addition, this down-valley flow of cold air sometimes arrives well after sunrise. Fruit has been damaged in this district by sudden drops in temperature occurring 1 and 1.5 hours after sunrise with a clear sky.

Then there is the topographic factor to be considered. A wind from any direction whatever, is moving either up or down slope, and the resulting effect upon the temperature may be quite noticeable. It also is necessary to distinguish between a general flow of air and a purely local wind. For example, a westerly wind that is a part of a cyclonic circulation will materially retard night cooling and may even cause a substantial rise, while a westerly wind that is merely cooled air draining to lower levels will be attended by a large fall in temperature.

On account of the pronounced morning temperature inversion characteristic of this and other districts of the semiarid West, and which is normally most pronounced in spring, a very moderate stirring of the air in the early morning following a clear, still night will raise the temperature materially. Many a carefully prepared minimum temperature forecast has thus been nullified by an early morning wind.

From what has been said, it is obvious that the calculating of minimum temperatures from hygrometric formulæ or from the evening radiational cooling is a very uncertain proposition. It also is clear that the probable direction and velocity of the wind is of as much importance to the forecaster as to the orchardist.

It has been found that the most reliable temperature forecasts are those made from the weather map, local influences being given due weight. But even here, the sparsity of reporting stations, and the entire absence of reports from the south (Mexico) inject a very large element of uncertainty into the forecasts. There are but three other Weather Bureau stations within a 300-mile radius of Roswell, as compared to 20 to 40 stations in similar areas in the eastern half of the United States, although within a 300-mile radius of Roswell can be found nearly every kind of climate found in North America. One needs a great deal of intuition to make satisfactory forecasts under such a handicap. A former district forecaster informed the writer that "Good forecasts are based upon general conditions, local influences and intuition, and of these intuition is the greatest."

Fortunately, the probable minimum temperature is of secondary importance to the orchardists, and is of very little interest to those who are equipped to meet any temperature that might occur. Next to the information that a freeze is impending, they consider the direction and velocity of the wind of paramount importance. Following a forenoon warning of freezing for the following night, the orchardist and his helpers begin shifting heaters to reinforce the windward side, if such shift be necessary. Next in importance is the hour at which critical temperatures are expected. We formerly allowed a margin of safety of 1 to 3 hours until we learned that the orchardists themselves were allowing a similar margin, after which we gave them the actual hour, as nearly as could be calculated. If freezing was expected for, say, 4 a. m., that hour was named in the forecast, but the orchardists were ready for action at 2 a. m., or even earlier, and sometimes this precaution was justified.

*The freeze of April 19, 1922.*—A large percentage of the fruit growers in this district had their first experience in orchard heating in the spring of 1922, and with few exceptions the experience was disastrous. Their heaters were too few and far between for the freeze of April 19, which, considering the state of the fruit, was the most severe freeze of record here. They were equipped for the freeze that normally occurs, but not for the one that *could* occur. Even some of the more experienced ones lost heavily, but the few old veterans in orchard heating brought their crops through safely.

Nevertheless, none of them are discouraged, and this commendable attitude is due to the experience of one orchardist, himself a novice, whose performance deserves mention in view of the fact that it was of incalculable value to the fruit industry in the Pecos Valley. This man was Dr. A. D. Crile, former president of the New Mexico Agricultural College, whose frost-fighting squad has been described herein. Before equipping his orchard with heaters, he spent most of one afternoon in the Weather Bureau office, going thoroughly into the records of spring freezes. Incidentally, taking the record minimum temperatures (rural) of 15 on April 4 and 26 on May 7, he calculated the *possible* minima for each intervening date. For April 20 he calculated a possible minimum of 21° (and a record-breaking minimum of 21° occurred in his district on April 19). Accordingly he equipped his orchard with sufficient heaters to raise the

temperature 10°, securing, at our suggestion, the smallest type of heater obtainable. Eighty of these were placed to the acre. During the frost season he called in person at the Weather Bureau office every time frost warnings were issued. Consequently, while his orchard was completely isolated and surrounded by bare prairie, with the additional handicap of being in the coldest spot in the entire valley on that night, he successfully fought the freeze of April 19 with 80 per cent of his heaters in action. Three days later we personally inspected his orchard at his request, and found no damaged peaches.

It always had been taken for granted that peaches could not be protected in this district, but when this man not only saved the crop but did it under two heavy handicaps, he proved beyond argument that every peach and apple in the valley could have been saved. Consequently, those who lost are preparing to double the number of heaters in their orchards, or, where unable to do this immediately, to concentrate their heaters upon a much smaller acreage. Instead of receiving a blow, orchard heating here has received an impetus. Even in the Grande Valley, with which this station is not concerned, orchardists, hearing of Doctor Crile's remarkable performance, are preparing to protect their extensive pear orchards next spring.

**Orchard heaters and thermometers.**—Small heaters were shown to be decidedly more effective, cost for cost, than large ones. "Small heaters and plenty of them" is the advice given by the veterans to the beginners. An ideal orchard heating system would be one that warmed a continuous layer of air next to the ground. "Small heaters and plenty of them" comes nearest to the ideal condition. One orchardist, who has saved a full crop of apples each spring for the last 12 years, declared that, while he is using the smallest, lowest heater obtainable, he would discard his entire equipment if he could secure a heater that is still smaller or lower.

At the suggestion of the writer, seconded by the county agricultural agent, a number of fruit growers last spring tried the experiment of placing the heaters directly under the trees. The results were so gratifying that in the future nearly all the orchards equipped with small, low heaters will be protected in this way. Portions of lower branches that were completely blackened with smoke suffered no damage and bore unblemished fruit.

The local farm bureau organization is preparing to publish working drawings of one of our model instrument shelters and distribute them to all fruit growers in the district.

#### A CLIMATOLOGICAL CALENDAR FOR COLUMBIA, MO.<sup>1</sup>

By GEORGE REEDER, Meteorologist.

The writer has compiled the mean minimum temperature for Columbia, Mo., for each day of the year for use in class work and as forming the basis of short informal talks before commercial clubs and organizations. He

has found so many interesting and instructive applications of these data that it seems desirable to outline the plan followed in the belief that his fellow workers will be benefited thereby.

The minimum temperature was chosen since it is largely the controlling factor in the vegetable world. After computing the means for the 32 years of record, they were assembled in groups. In forming the groups all temperatures within a range of 5° were put in the same group, thus all values between 15° and 20° were put in one group, all those between 21° and 25° in the next and so on up to the highest group which has a mean of 65.7°. As illustrating the time limits and the mean values of the different groups the table below is given:

TABLE 1.—Mean minimum temperature, Columbia, Mo., by groups of significant dates.

Inclusive dates.	Mean temperature.	Significant dates.
Feb. 11-22.....	22.4	The beginning of the annual upward march.
Feb. 23-Mar. 7.....	26.1	
Mar. 8-17.....	31.3	Mean minimum, Mar. 13, 33°; time to sow oats.
Mar. 18-22.....	35.0	
Mar. 23-Apr. 4.....	37.9	Mean minimum, Mar. 25, 38°; time to plant Irish potatoes.
Apr. 5-17.....	41.4	Mean minimum, Apr. 15, 42°; corn planting begins; Apr. 21, peaches and apples in blossom.
Apr. 18-May 2.....	47.5	
May 3-18.....	51.3	
May 19-June 2.....	57.2	
June 3-23.....	63.2	June 3, mean minimum, 60°; summer begins.
June 24-Aug. 20.....	65.7	July 9-11, three consecutive cooler nights; July 13-17, 5 consecutive warm nights.
Aug. 21-Sept. 11.....	61.0	Corresponds with period June 3-23, but in reverse order.
Sept. 12-25.....	56.4	
Sept. 26-Oct. 5.....	51.7	Time to sow winter wheat.
Oct. 6-18.....	46.8	
Oct. 19-26.....	42.5	
Oct. 27-Nov. 10.....	38.1	
Nov. 11-27.....	31.8	
Nov. 28-Dec. 11.....	26.4	
Dec. 12-Jan. 29.....	21.6	Jan. 12-13, two coldest days of winter; mean minimum, 14° and 16°, respectively.
Jan. 30-Feb. 10.....	17.8	The coldest 12-day period.

After assembling the daily means in groups and computing the group means it was found that the period from January 30 to February 10, inclusive, gave the lowest group mean, viz. 17.8°. That period therefore served as the starting point for the upward march of the group means. The date February 11 has therefore received the initial number in the consecutive series of 366 days.

Many interesting facts can be drawn from the series of means, as, for example, the dates of planting staple garden vegetables, the sowing of grains, etc. Other interesting features from a climatological standpoint are the lowest daily means for five consecutive days—the time of the greatest consecutive severe cold of the winter falls on February 1 to 5, although the absolute minimum for the year falls on January 12. A week later, January 19-23, is the date of the so-called "January thaw," during which time the mean minimum rises to 28° on January 20, immediately dropping to 23° on the 21st. Is there any relation between these two events? Many other interesting comparisons may be made.

<sup>1</sup> Condensed from the original manuscript.